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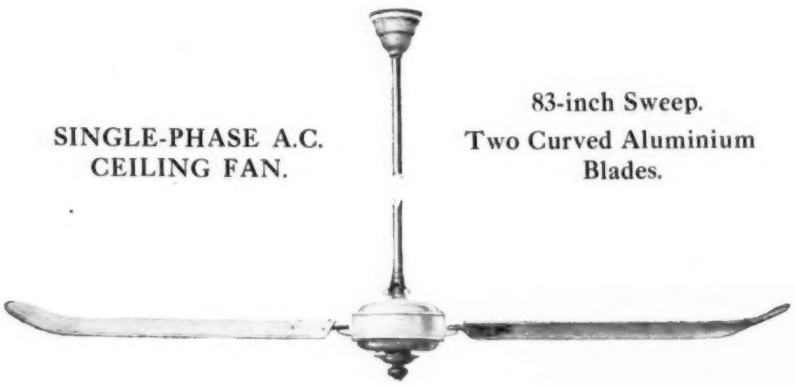

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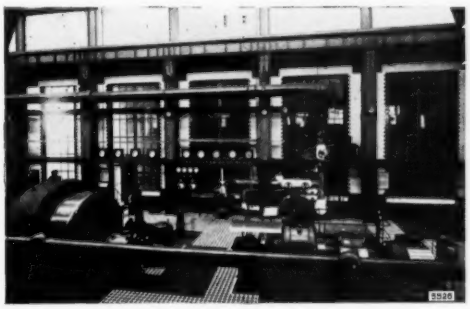

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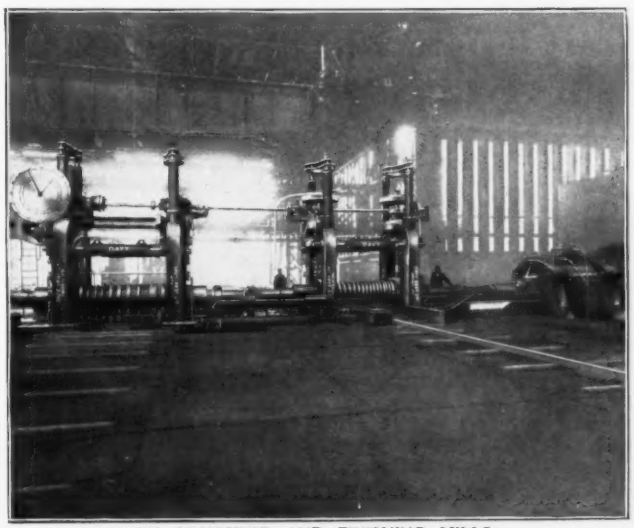

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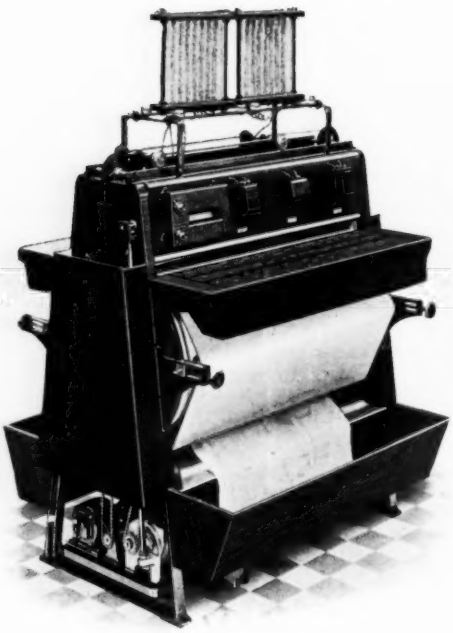

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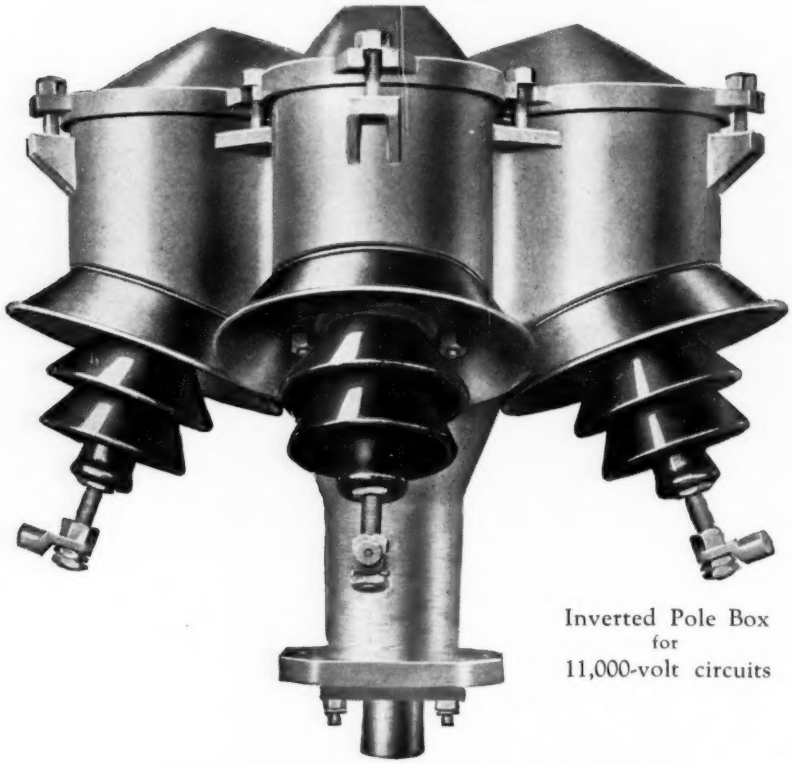

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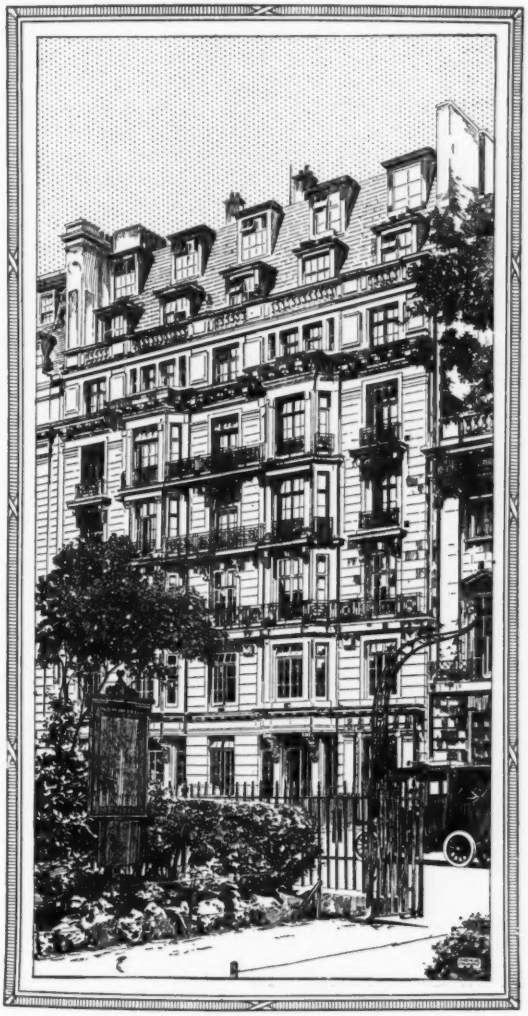

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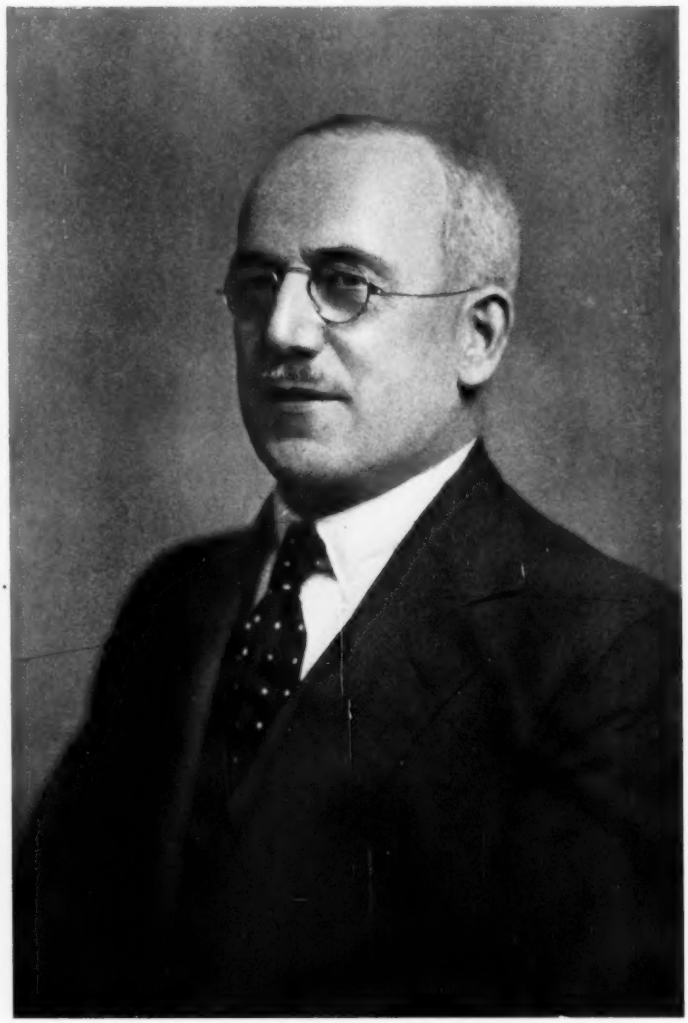

The New Chairman of The English Electric Company

Sir Holberry Mensforth, K.C.B., C.B.E., M.Sc.

The English Electric Journal

Vol. V. No. 3 JULY, 1930 One Shilling.

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All Communications respecting Editorial Contents should be addressed to THE EDITOR, THE ENGLISH ELECTRIC JOURNAL, QUEEN'S HOUSE, KINGSWAY, LONDON, W.C.2.

EDITORIAL.

The description in this issue of a large modern switching equipment of the metalclad type serves to draw attention to the importance of maintaining this section of existing power stations up to a standard that is commensurate with the growth of the load and with the highest possible degree of reliability and safety. Switchgear that has been good enough in the past may give quite inadequate control under the conditions presented by larger individual generating units, greater total plant capacity, and interconnection with other stations.

In replacing the former switching arrangements at Greenwich, the main apparatus has been removed from the machine room to a new fireproof building, which is subdivided into two compartments, and the circuit-breakers have been designed for electrical operation from a control board overlooking the turbines. The high factor of safety given by this arrangement is still further

increased by appropriate grouping of the circuit-breaker units and busbars and the provision of a duplicate busbar system with a change-over switch on each metalclad unit for transferring the circuit from one set of bars to the other.

In addition to its special technical merits, metal-clad switchgear of this type is particularly advantageous in cases of reconstruction, because its extreme compactness either permits the freeing of space for other purposes, or, if new accommodation is necessary, reduces the ground space and buildings to the smallest possible dimensions.

The record, which we continue from previous issues, of the Company's work in meeting the demand for electric trolley buses is brought up-to-date in this number by a description of two new vehicles and their control equipment. This series of articles will indicate to our readers how the marked expansion of trolley bus services that is occurring is accounted for not only by their flexibility in traffic, low running costs and ease of driving, but also by reason of the higher standard of passenger comfort which they confer.

We hope that those who are responsible for supplying and for using electric power for factory drives will be encouraged by the article on power factor correction to explore the possibility of obtaining economies similar to those we record. An investigation of the possibilities of improving the power factor in many factories where as yet no attention has been paid to this matter, might well lead to results comparable with those obtained in the cases cited.

New E.H.T. Switching Installation at the Greenwich Power Station of the London County Council.

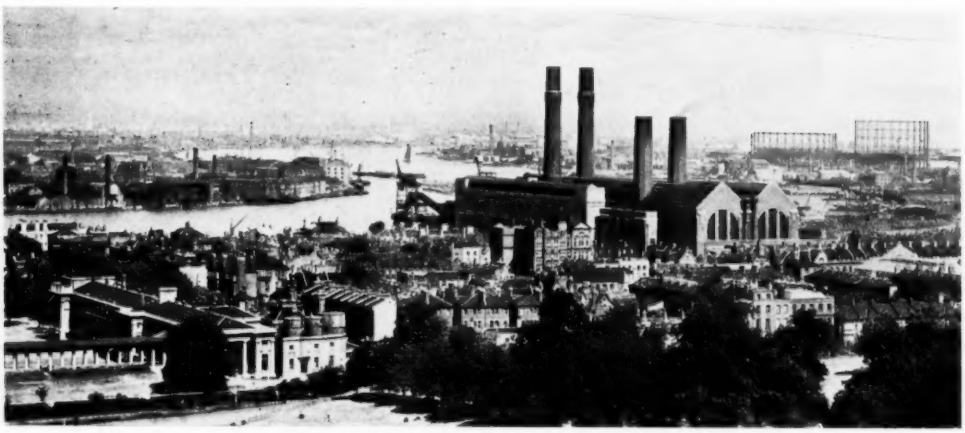


Fig. 1.—Greenwich Power Station is the central feature of this Panorama.
[By Courtesy of "The Times."

Power for the tramway system of the London County Council is supplied from the Council's own Generating Station at Greenwich. Even when judged by modern standards, this station, which was erected many years ago, is a very fine one; it is a conspicuous landmark on the River Thames, easily recognisable by the fact that two of its four chimney shafts were built considerably shorter than the others, in order to comply with the requirements of the Admiralty in connection with Greenwich Observatory. The vast size and importance of this tramway system, which

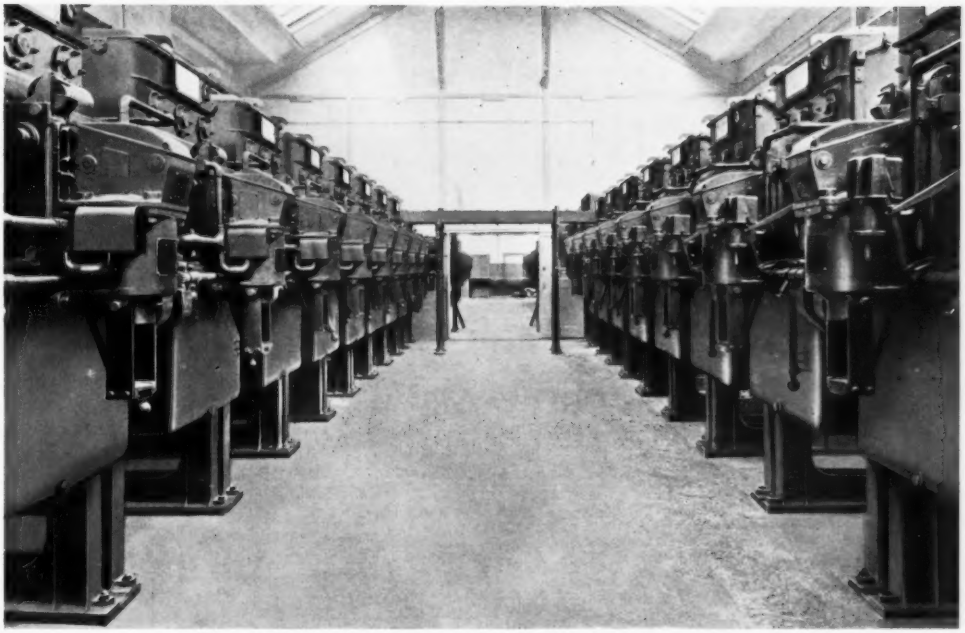


Fig. 2.—General view of the New Switch House from the South Room.

carries over two million passengers a day and runs day and night, renders continuity of service essential, and, therefore, it is necessary for a constant watch to be kept on the whole of the generating and converting machinery, switchgear, mains, etc., not only to see that they are maintained at maximum efficiency, but also that they are suitable in all respects for dealing with the general expansion of the system. In this connection it may be remarked that switchgear in particular has been the subject of considerable development, due in part to the great increase in plant capacity and in the size of individual generating units.

About two years ago preliminary proposals were made by the Council for the complete reconstruction of the switchgear at Greenwich. The merits of different types were fully considered and careful investigation was made concerning the relative advantages of cellular and metalclad compound-filled gear. Eventually a contract was awarded to The English Electric Company for the whole of the reconstruction work, including the supply of the Company's compound-filled switchgear, with control boards, engine room signals, oil purifying equipment, and a number of miscellaneous items necessary for the completion of the installation.

It will be appreciated that no interference with the operation of the tramway system was permissible at any stage of the work, and accordingly it was necessary to arrange for changing over the generator and feeder cables one at a time in accordance with a carefully prepared programme, and to keep the original switchgear in service until the change-over was completed.

The Switch House.

An entirely new switch house has been built adjacent to and on the same level as the existing switchgear gallery on the north-east side of the turbine room. It was specially designed to accommodate the type of compound-filled units selected. The new building is divided into two equal compartments by a transverse dividing wall of fireproof construction, communication between the two compartments being given by

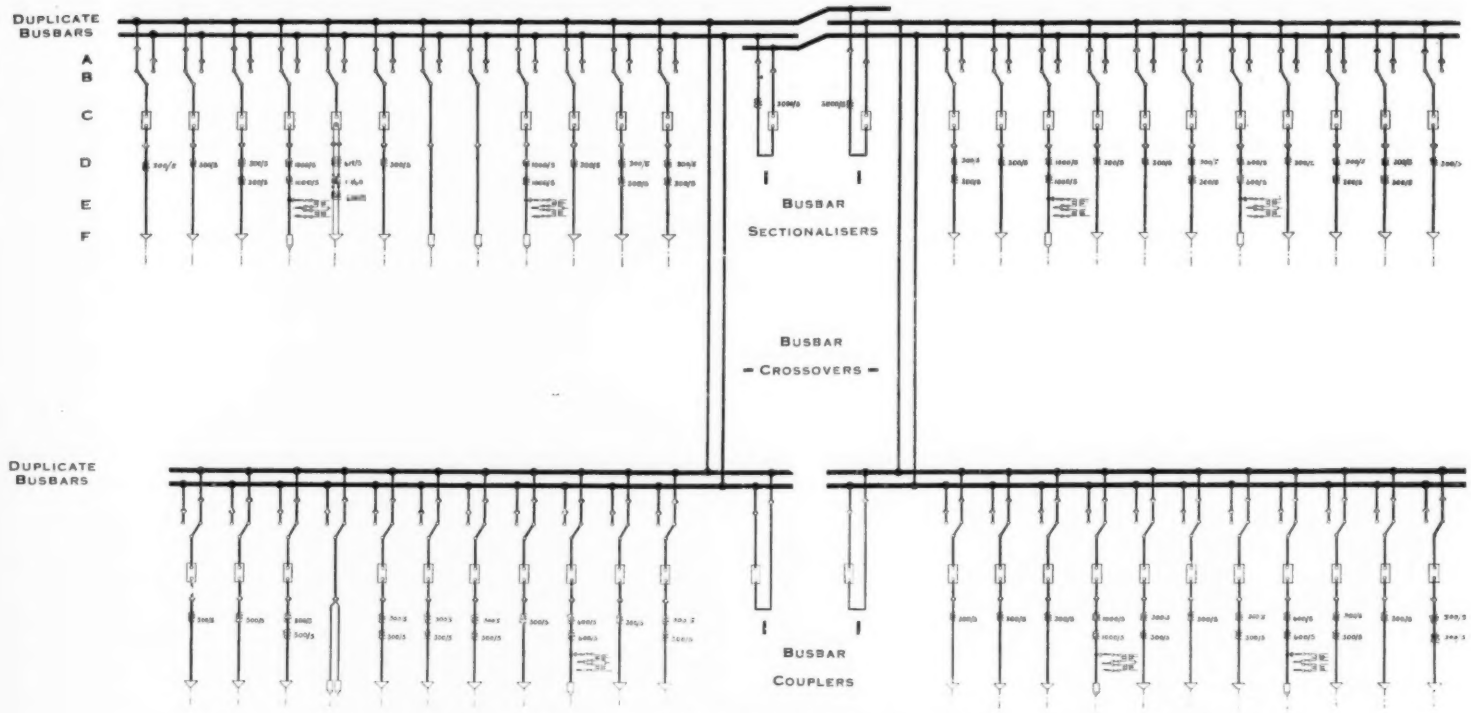


Fig. 3.—Layout of the Metalclad Switchgear in the new Switch House.

a central fireproof door. By placing half of the switchgear in each compartment and arranging the circuits so that the system can be operated as two distinct sections, each complete in itself, an important safeguard has been provided against the risk of the whole service being dislocated in the event of a mishap to any portion of the switchgear. While the two halves can be operated independently, provision is made for coupling them when desired by means of suitable section switches, and the two halves are connected by compound-filled busbar trunks which pass through the fireproof barrier. In each room the switchgear is arranged in two lines with a main central alleyway, and with sufficient room between the backs of the units and the walls to permit the necessary access. Each room is served by a three-ton crane.

Main Metalclad Switchgear.

The main switchgear consists of 49 units of The English Electric Company's "OLF" Type, designed to operate at 11,000 volts. Duplicate busbars are provided throughout, and the oil circuit-breakers are electrically operated. Figs. 2 and 4 show the general arrangement of the four banks of metalclad gear and Fig. 3 the lay-out of the electrical components of the system. Connection between the duplicate busbars in the two compartments is effected by bus coupling switches in each room. In the case of the feeder and generator control units, connection is made to one or other of the duplicate busbars by means of an oil-immersed selector switch carried on the moving carriage of each unit. These switches are operated by means of hand-wheels, and are fully interlocked with the circuit-breaker on the unit to ensure that load is not broken on the selector switch. Of the 49 units installed seven are for generators, thirty-five for feeders, and three for tie feeders, while two are bus section units and two bus couplers.

Three of the generators are protected by the biassed system of protection, and the other four by Merz-Price circulating current protection.

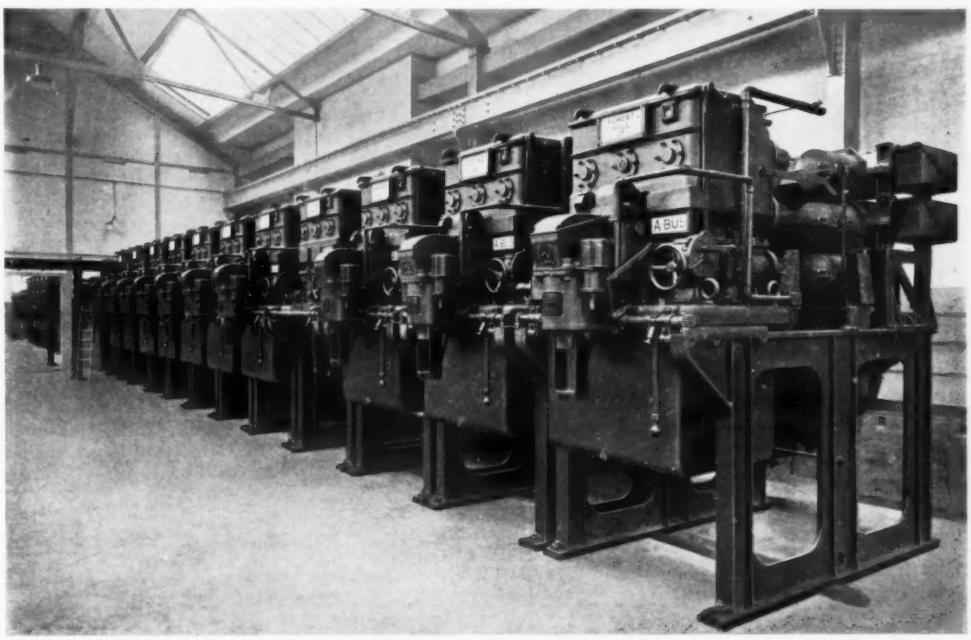


Fig. 4.—West Bank in North Room. The moving carriage of the nearest unit is in the isolated position.

Fig. 5.—Main Control Board for electrical operation of the Metalclad Units.

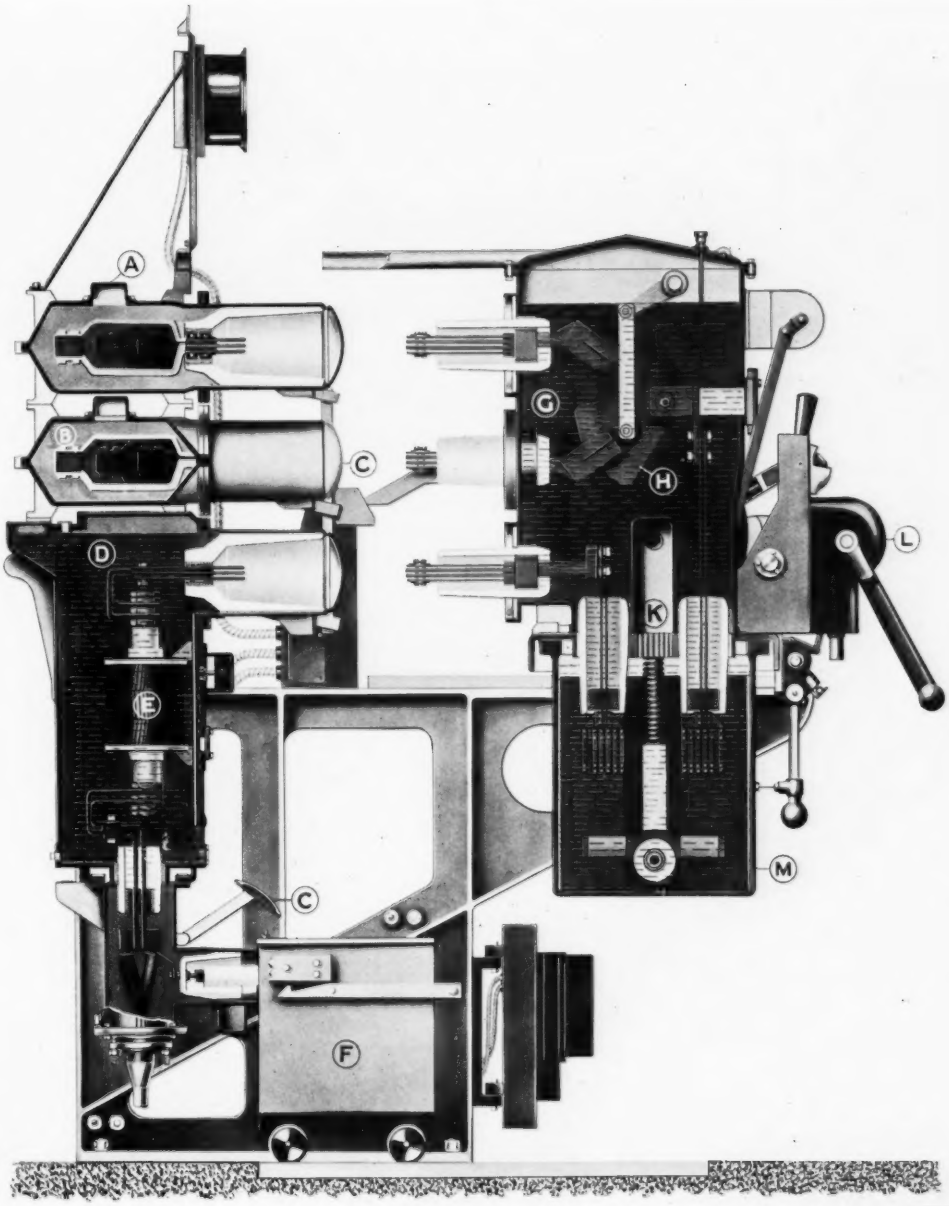
Most of the feeders are parallel feeders consisting of two or more cables serving a particular sub-station, and in these cases biassed parallel feeder protection is installed, and so arranged as to give stand-by overload and leakage protection on a healthy feeder after a faulty one in parallel with it has been cut out of circuit. All current transformers necessary for the protective systems, as well as the instrument current transformers, are housed at the rear of the units in chambers completely filled with oil. The use of oil for this purpose is finding considerable favour at the present time on account of the facility which it gives for changing a transformer in case of trouble, or in the event of the ratio having to be altered ; the carrying out of such work is obviously much simpler than if the chambers were filled with solid compound. The oil used by The English Electric Company for this purpose has a consistency like vaseline at ordinary temperatures, and is about the thickness of heavy engine oil at 120° F.

A feature of the installation is that normally the bus coupling switches remain closed, with the main generating units and all tramway feeders connected to one set of bars, and one of the smaller generating units connected to the other set. The last mentioned unit is the one used for the various auxiliaries in the station. A low-voltage release is fitted on the coupler switches, and in the event of a serious fault on the tramway system causing a drop in voltage, the release operates and opens the coupler switch, thus leaving the auxiliary generator running on its own bars clear of trouble or possible shut-down.

The two rows of compound-filled units in each half of the switch house are connected near the dividing wall by compound-filled busbar trunks carried overhead on substantial tubular supports of ample rigidity to withstand shocks due to short circuits or other causes.

The opening and closing of the oil circuit-breaker on each switching unit is performed by means of a solenoid operating mechanism mounted at the front of the unit, the necessary contactor gear being housed in a metal cabinet at the rear ; the operating buswires are run in steel conduit at the back of each row of units. For lowering and replacing the oil tanks, a special carriage is provided, while the moving portion of any unit can be removed complete by means of the travelling crane.

The construction of " English Electric" metal-clad units with duplicate busbars and selector switches is illustrated by the diagrammatic section in Fig. 6 ; the circuit-breaker in the example shown is hand-operated.



A. Expansion Domes prevent leakage of Compound.—**B.** Busbars fully insulated for system voltage.—**C.** Automatic dust-tight and vermin-proof shutters.—**D.** Current Transformer Chamber oil or compound filled; oil facilitates changing transformers.—**E.** 3 Current Transformers per phase can be fitted (except size O L D—2 only).—**F.** Oil-immersed Potential Transformer. Fuses under oil and can be changed without opening main circuit.—**G.** Oil-immersed changeover Selector Switch.—**H.** Fan blade for changing over under load.—**K.** Patented Vent System.—**L.** Trip-free operating gear; totally-enclosed front. Electrical operation by solenoid or motor, if desired.—**M.** Heavy boiler plate tank to withstand internal pressure.

Fig. 6.—Diagrammatic Section of "English Electric" Metalclad Unit with duplicate busbars and On-load Selector Switch; the Moving Carriage is shown withdrawn.

Control Board.

The main control board is installed on the old switch gallery adjoining the new switch house. It is constructed of ebony Sindanyo panels carried on a steel framework, and consists of a central section and two flank sections running at right angles at either end, so that the whole structure forms three sides of a rectangle. The centre portion of the board controls the generators, and the two flank sections the feeders. A special feature of the feeder panels is that no meters or relays are mounted on them, but these auxiliary pieces of apparatus are accommodated on two separate boards situated at a short distance on either side of the main control board. With this design it has been possible to keep the essential controls and indications relatively compact and conveniently central for the operators.

A bold connection diagram runs the full length of the top of the control board, and is provided with electrically-operated semaphores, which give immediate indication of the opening or closing of the oil circuit-breakers and selector switches. Another example of the way in which the convenience of the operators has been considered is the arrangement of the control switches for the generator circuit-breakers. These switches, together with those for the control of the turbine governor motors and for the circuit-breakers in the neutral, are mounted on the exciter rheostat pedestals which are fixed in front of the control board in a position which gives the operator an excellent general view of the synchronising instruments, semaphores, etc., on the board.

The oil circuit-breaker control switches are interlocked with the synchronising gear in such a way that it is impossible to close a breaker unless the synchronising plug has already been inserted in the appropriate socket on the control panel. For emergency operation there are trip switches operated by push buttons on the panels.

In the case of the feeder equipments, all the control switches are mounted on the main control board.

The back of the control board is completely enclosed by sheet steel, with steel dividing barriers and doors, thus giving a construction which permits easy access, but is, at the same time, practically dust-proof.

By mounting the relays and meters for the feeder circuits separately from the main control board, as already described, it has been possible to obtain a very compact arrangement of the feeder circuit panels. Two groups of circuits are accommodated on the upper half, and two on the lower half of a panel, with the corresponding diagram above each pair of units. By this arrangement, which can be clearly seen in the illustration, Fig. 5, all the controls are concentrated at one point, while the secondary apparatus on the separate auxiliary boards is fully accessible for inspection without any interference with the control board proper.

The engine room signalling apparatus was supplied by Messrs. Siemens Brothers & Company, Ltd., and follows generally their well-known designs, with slight modifications to meet the requirements of the Council's Engineer. A separate system of signalling is employed for the two halves of the new switch house known as the North and South sections respectively.

The oil purifying equipment was supplied by Messrs. Super Centrifugal Engineers, Ltd., and is of the well-known Sharples portable type.

The whole of this important contract has been carried out to the specifications of the London County Council. Grateful acknowledgment is made to the Council's staff for the valuable assistance they rendered in the execution of the work, and also to the Council for permission to publish this description.

Profitable Power-Factor Correction.

It is probable that in spite of all that has been written on the subject of power-factor improvement, the majority of power users still do not realise the important part which they must play if the average level of power-factor is to be raised. Low power-factor at any point of an alternating-current network means waste; that is to say, additional capital or running expenditure for which no ultimate return is obtained. As with other forms of wastage which occur in practical engineering, the extent to which the evil of low power-factor can be alleviated is determined by the cost of the remedial measures adopted, but on the other hand the introduction of improved and cheaper methods of power-factor correction entirely alters the aspect of the economic problem, especially if the power supply authorities—who are the greatest sufferers from low power-factor—offer adequate inducement to their customers to make use of the available remedies.

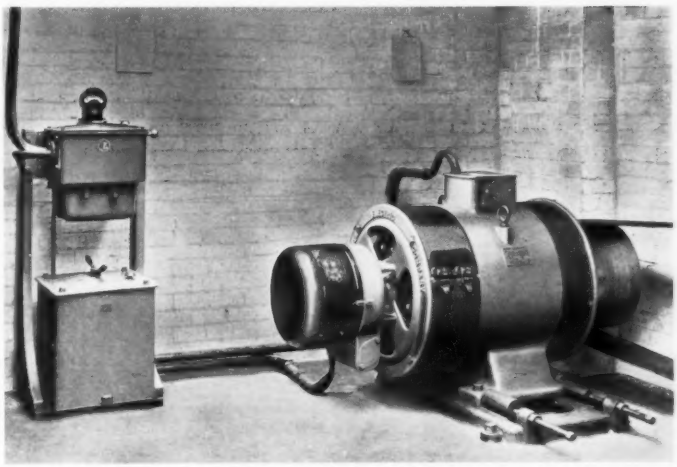


Fig. 1.—75 H.P. "Kosfi" Motor and Control Gear for Compressor Drive. Feeder Power Factor 0·93.

Since the introduction of the "English Electric" Compensated Induction Motor, to which the name "Kosfi-Leading" has been given, this Company's engineers have studied the power-factor question in a large number of factories, mostly of small and medium size, and where they have recommended the installation of "Kosfi" motors as justifiable on economic grounds, highly satisfactory results have been obtained. In all cases the result has been a substantial and often quite considerable financial gain after compiling proper balance sheets representing the old and the new conditions.

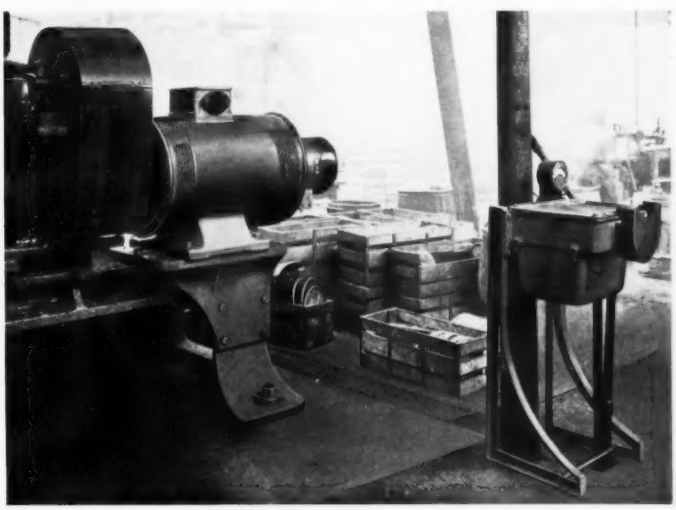


Fig. 2.—30 H.P. "Kosfi" Motor driving a Power Press. Installation Power Factor raised from 0·63 to 0·85.

Before giving some particulars of representative cases, it may be of service if a brief description of the motor and its method of operation is given. The "Kosfi-Leading" motor is an induction

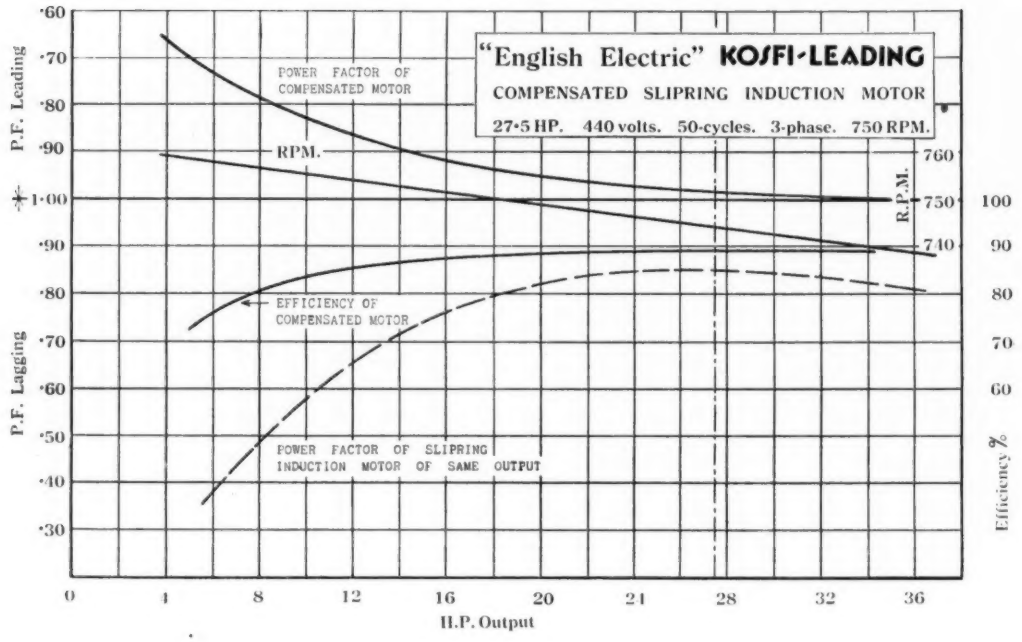


Fig. 3.—Specimen Characteristic Curves.

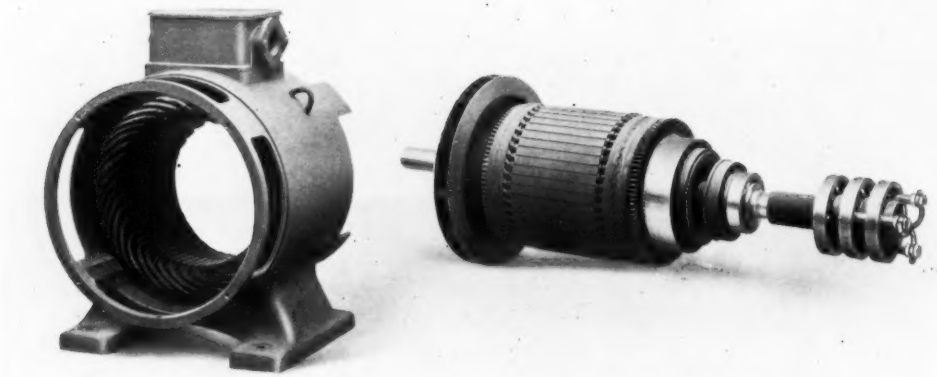


Fig. 4.—Stator and Rotor of 20 H.P. Compensated Slipring Motor.

motor, in which the roles of the stator and rotor are reversed, in that power is fed into the sliprings, while the stator forms the secondary winding working at slip frequency. In addition to the normal power winding the rotor has an entirely separate auxiliary winding connected to a commutator having three-phase brushgear from which connections are taken to the stator winding through a starter, as shown in Fig. 5. Fig. 4 illustrates the stator and rotor of one of these machines.

Since the auxiliary winding on the rotor is always exposed to a rotating flux of line frequency, the voltage induced in it has a constant value, irrespective of the speed. As, however, the brushes are stationary, the voltage between them is always at slip frequency, which is naturally the only frequency suitable for injecting current into the secondary winding on the stator. It follows, therefore, that by connecting the brushes to the stator winding, an exciting current can be fed into the secondary; by rocking the brushes on the commutator the phase of this exciting current can be adjusted, with the result that the power-factor of the secondary, and therefore of the primary or line circuit, can be adjusted to any value within the limits of the particular design. In normal cases the motors are designed for about .98 leading power factor at full load, and unity at from 25 per cent. to 40 per cent. overload.

It should be observed that these motors not only take no magnetising current from the line, but that they are able to supply some leading wattless current to counteract some of the magnetising current of any induction motors in the installation. This great advantage is obtained at a moderate increase in cost above that of a standard slipring induction motor, and as will be seen from the examples given hereafter, the extra cost is quickly recouped in all cases where the supply company's tariff takes into account the power-factor of the consumer's load. Where considerable power-factor compensation is not necessary, the motors are designed to give unity or slightly leading power-factor between no load and 1½ times normal full load.

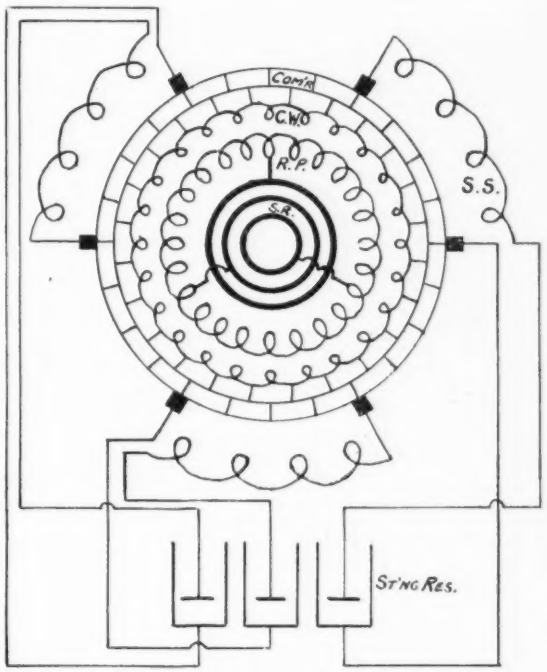


Fig. 5.—Connections of "Kosfi-Leading" Motor.

At unity power-factor a compensated machine and control gear may cost possibly 50 per cent. more than an induction motor, but in terms of cost per wattless kVA. compensated for when working at 0.7 power-factor leading, it will be equivalent to an induction motor plus 40/- down to less than 20/- per kVA., depending on the size.

As the power is fed into the sliprings, the "Kosfi" design of compensated motor is suitable only for low voltages, that is to say, up to 1,000 volts, but the field of application is very wide since it enables a unity or leading power-factor machine to be installed on small drives.

As will be seen from the specimen characteristic curves shown in Fig. 3, the efficiency curve is high and flat, the efficiencies being actualiy somewhat better than for a standard slipring induction motor of similar rating and speed. An important advantage of these motors is that they have a greater overload capacity than the synchronous type of machine or even of an ordinary

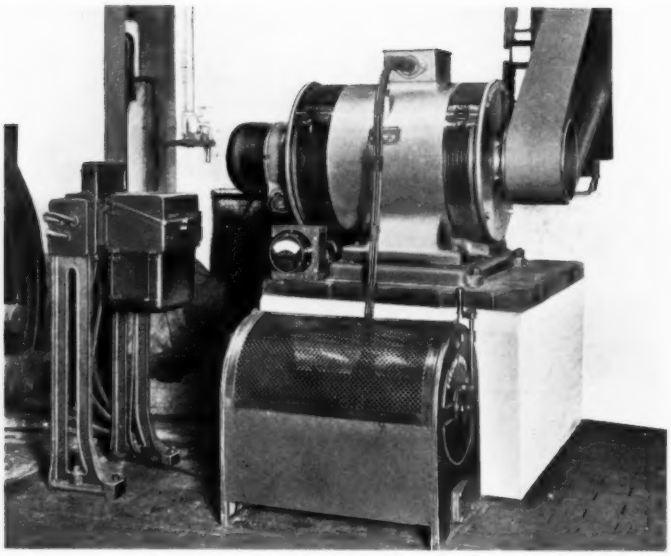


Fig. 6.

60 H.P. "Kosfi" Motor and Control Gear in a Foundry. Installation Power Factor 0·98.

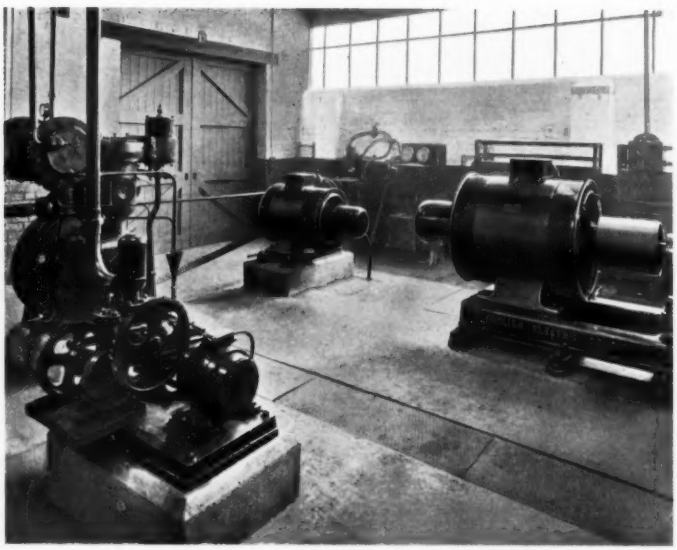


Fig. 7.

120 H.P. and 60 H.P. "Kosfi" Motors in a Boiler Works. Installation Power Factor 0·92.

induction motor, very much so on a leading power factor, and they are not liable to fall out of step until the maximum stalling torque is reached. The ratio of starting torque to starting kVA. is equal to, or better than, that of an ordinary induction motor, and considerably better than that of a synchronous induction motor.

It should also be noticed that the new motor has the same slightly drooping speed characteristic as an ordinary induction motor, so that sharp peak loads are able to draw on the kinetic energy of the rotor and any coupled masses, and peaks in the energy drawn from the mains are thereby flattened.

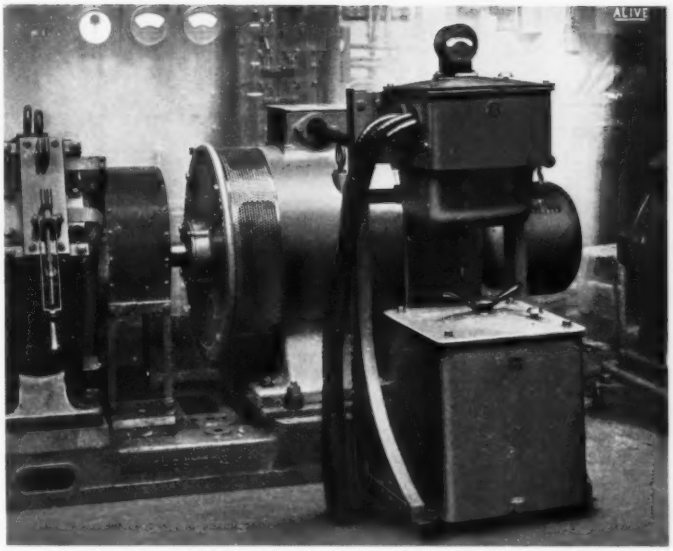


Fig. 8.—75 H.P. "Kosfi" Motor driving D.C. generator. Feeder Power Factor 0·93.

Fig. 6 shows a 60 h.p. "Kosfi" motor operating in a large foundry in the Midlands. Prior to its installation the power-factor was about .6, but as a result of the compensated motor working at .85 power-factor leading, the overall power-factor is now maintained at .98. The customer to whom this motor was supplied has stated that although he was sceptical as to the realisation of the economies predicted, his experience of the working of the motor has fully borne out the claims made for it, and, further, that the savings are within about 2 per cent. of those estimated, in spite of the somewhat scanty information on which the calculations were based. He was satisfied that the reduction of his power bill was such that the cost of the motor would be saved within the period given.

In another case the total load of a factory is about 1,200 kVA., in comparatively small units, and is taken from four separate feeders. Two 75-h.p. "Kosfi" Motors have been installed on the section supplied by one feeder, one driving an air compressor, and the other a D.C. generator, which is used alternatively for lighting or for welding purposes. These two machines are illustrated in Figs. 1 and 8.

The motors were designed for a leading power-factor of .7 and have improved the power-factor of the feeder on which they operate from .65 up to .93. As the result of running the installation for about five months it was proved conclusively that a saving of approximately £20 per month had been achieved, which meant that the extra cost of installing this type of motor, as compared with induction motors, will be wiped out in twelve months.

Fig. 7 shows two "Kosfi" machines of 120 h.p. and 60 h.p. respectively, installed in an engineering works having an average power load of 450 kVA. The larger motor operating at .55 leading power-factor has taken the place of a gas engine, and the smaller motor operating at .9 power-factor leading drives the air compressor seen in the picture. The power-factor of the installation as a whole has been improved from .73 lagging up to .92. Great satisfaction has been expressed at the financial result obtained in this case, as the amount of wattless kVA. recovered has exceeded the figures guaranteed. With the present conditions of load this customer is saving very nearly 550,000 wattless units per annum, equivalent to a yearly saving of £200.

Fig. 9 illustrates a 95 h.p. "Kosfi-Leading" motor driving an air compressor in a large

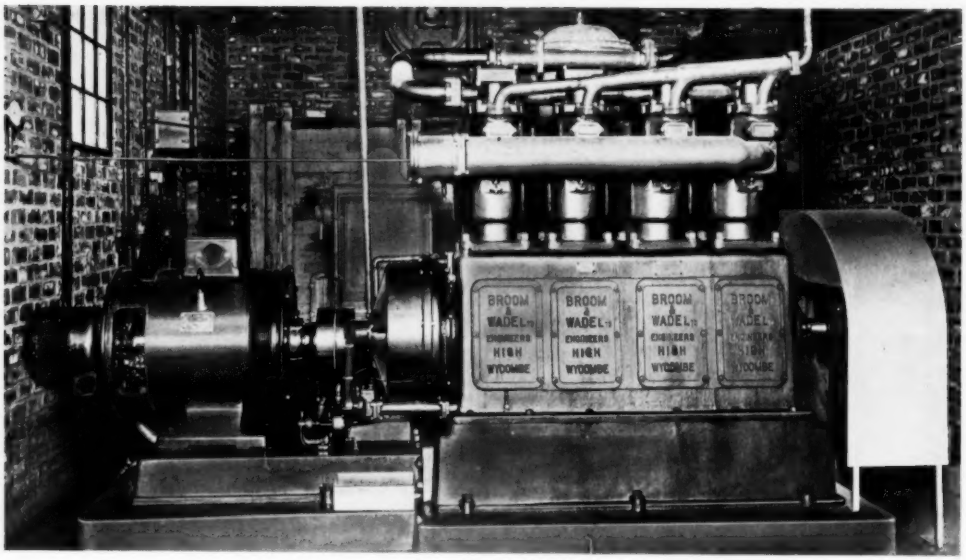


Fig. 9.—95 H.P. "Kosfi" Motor Driving an Air Compressor.

engineering works where electric power is taken from the public supply. By installing this machine the power-factor of the whole installation was raised by some 25 per cent. and a rebate of 5 per cent. secured on the total power bill, amounting to £100 a year. Fig. 2 shows a 30 h.p. "Kosfi" motor operating a power press; in this case the power-factor of the factory has been improved from .63 to .85.

As an example of the more general advantages of improved power-factor from the point of view of its effect on the generating plant, reference may be made to the installation in each of a group of food factories of a 100 h.p. "Kosfi" motor. Each of these factories has its own generating station, and it was found that the improvement in the system power-factor was such as to permit one alternator to be dispensed with; at the same time the voltage regulation throughout the factory was much improved.

It may be pointed out that the maximum advantage of installing the type of motor described, is obtained when they are used for continuous drives of good load factor, such as compressors, motor-generators, line shafts, pumps, etc.

More Fullagar Engine Plant Ordered.

It is no small testimony to the satisfactory operation of this type of plant to have received a further repeat order from the **Admiralty** for two 6-crank, 750-kW. direct-current sets. Two similar sets were put into commission in February and June, 1929, and a third set was ordered and started up last January.

The **Delhi Electric Supply Company** have ordered an engine of the same size directly coupled to an alternator. The station in which this unit will be installed contains four of the Company's standard four-stroke Diesel engines each of 500 h.p.

Some New Trolley Buses and their Control.

The last issue of this Journal contained illustrations and brief particulars of trolley buses for several transport undertakings at home and abroad. The opportunity was taken also to refer to the new line of vehicles which is being put on the market in conjunction with the Associated Equipment Company. If excuse were necessary for including in this number a somewhat more detailed description of trolley buses that have been completed in the past few weeks, it would be based upon the great interest taken in this type of vehicle by road transport authorities in all parts of the world, as well as upon the considerable amount of development work which is being carried out by the English Electric Company in this field.

Fig. 1.—"English Electric" 59-seater in service at Southend.

The vehicles now described are representative buses of the "English Electric" type, and "A.E.C.-English Electric" type respectively, each design having certain distinctive features in the power equipment and body design with a view to meeting varying local conditions. The control equipment is of this Company's latest contactor type and the design and arrangement are generally similar on both vehicles.

In Figs. 1 and 2 are shown buses recently put into service by the Southend Corporation. These double-deck six-wheeled vehicles were constructed throughout at the Company's Preston Works, and contain the latest improvements in mechanical, electrical and body-work design. The chassis have a group system of lubrication which reduces the number of lubricating points to a minimum and ensures that they are in the most accessible positions for efficient maintenance. As is customary with most "English Electric" trolley buses, a triple system of braking is provided, hand, compressed air, and electric. The control system, which is described in some detail later, comprises a contactor-type series-parallel controller actuated electrically from a foot-operated master controller. The motor is a double-armature light-weight machine having a one-hour rating of 80 h.p., and is fitted with roller bearings.

Considerable care has been given to the comfort and convenience of the passengers when travelling, and entering or alighting. Noticeable features are the additional exit at the front and the stepless platform, which is only 14 inches above the ground. In one of the views the bus is shown carrying a load much in excess of the normal complement of 59 passengers, but the riding qualities and accommodation give generous margin for rush-hour traffic of this kind.

Other illustrations show one of several "A.E.C.-English Electric" buses that have been

Fig. 2.—Two "English Electric" Trolley Buses recently added to the Fleet of the Southend Corporation.

Fig. 3.—An "A.E.C.—English Electric" Trolley Bus ready to leave Preston Works.

built and exhibited in various parts of the country before going into service. It will be remembered that the most distinctive feature of this design is the placing of the motor at the front of the chassis so that practically the whole of the electrical equipment is centralised in or close to the driver's cab, and is rendered accessible by the provision of a removable louvre panel. The arrangement is clearly seen in Figs. 4 and 6. The chassis of the bus is the "Renown" model of the A.E.C., while the body, driving and control equipment are of standard "English Electric" construction. On the mechanical side there are no departures from the current practice of the two companies; triple braking is fitted, and a third differential is interposed between the drives to the two back axles. It will be noticed from the view of the chassis in Fig. 5 that the motor-driven air-compressor is mounted compactly on top of the main motor.

Fig. 4.—Head-on view of "A.E.C. English Electric" Vehicle showing removable Louvre Panel.

The control arrangement fitted to both of the buses illustrated in this article represents the latest development directed to reducing the number of separate operations which the driver has to perform. It is indeed one of the advantages of the electric bus that it is possible to simplify the driving and reduce the strain on the driver, who is responsible not only for the steering but also for the application of the power and the brakes.

In the equipment now described all power and brake applications are achieved by the use of two pedals and a hand-brake lever. This has been carried out in practice by the use of solenoid-operated contactors designed to meet the special conditions met with in railless traction. The essential parts of the control equipment are: —

Master Switch.
Reverser.
Contactor Panel.
Current Limit Relay.
Brake Switch.

The master switch, which, in the case of the

Fig. 5.—Three-quarter near-side view of "A.E.C.-English Electric" Model "663 T" Trolley Bus Chassis with electrical equipment.

"A.E.C.-English Electric" vehicle, can be seen at the extreme front of the chassis, Fig. 5, controls the operation of the contactors and ensures that they open and close in the correct sequence. Fig. 8 illustrates this piece of apparatus; it is a drum-type switch of robust design operated by a pedal and lever so proportioned that the effort required is quite small and compares favourably with that necessary in the case of the accelerator of a petrol vehicle. As the current carried by the master switch contacts is quite small, the arc at breaking circuit is negligible, and since, moreover, the contact fingers are substantial and adjustable and provided with renewable tips, maintenance becomes a very simple matter. In the case of a single-motor trolley bus the master switch has six notches, of which one can be used for field shunting, if desired, while in the case of a twin-armature motor equipment there are eight notches, either four series and four parallel, or four series, three parallel and one field shunt, according to requirements.

Mounted in the same case as the master switch and interlocked with it is the reverser, and this can only be moved when the master switch is in the "off" position. This reverser is hand-operated and cannot be moved from one position to the other while power is being supplied to the motor.

The bank of contactors (Fig. 7) is mounted in a compact asbestos-lined steel case having a removable cover, and each unit has its own blow-out device with a removable arc chute made of a special grade of heat-resisting material. The contactors are built up of interchangeable parts and have renewable contact tips and auxiliary fingers.

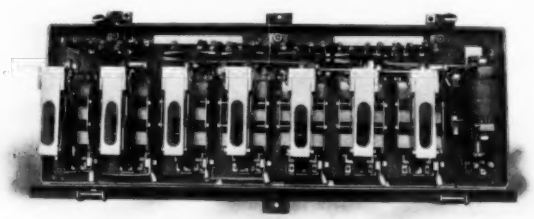


Fig. 7.—Electrically-operated Contactor Type Motor Controller.

Fig. 6.—Method of obtaining access to electrical equipment on "A.E.C.—English Electric" Bus.

In the same case as the contactor group there is a current-limit relay, the purpose of which is to regulate the acceleration automatically. The first and second notches of the master switch are completely under the control of the driver, but when the master switch is moved to the further notches, operation of the corresponding contactors is controlled by the current-limit relay, which is set to the particular value of current desired. After the driver has reached the second notch he can depress the master switch pedal to its full limit without any harmful effect on the electrical equipment, and this is clearly a safeguard which every driver will appreciate. On the last field notch the setting of the relay is adjusted automatically by the bringing into circuit of an auxiliary coil, an adjustment that is required with field shunting, owing to the rise in the current when moving from full field to shunt field conditions.

The control equipment outlined above can be extended to include rheostatic braking, if this is required. The only

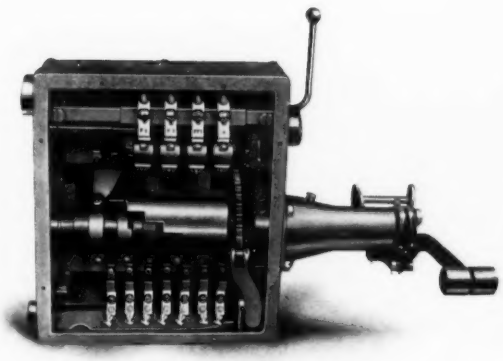


Fig. 8.—Foot-operated Master Controller and Reverser.

additional apparatus is a brake switch, and this is operated from the same brake pedal that is used to bring the air brakes into action. The arrangement is such that the initial depression of the pedal operates the brake switch and applies rheostatic braking, while further downward movement applies the air brake while still retaining rheostatic braking. Electric braking acts through the transmission, and as it is unwise to put any undue strain on this vital part of the chassis, "English Electric" rheostatic braking has been so graded that it acts in a similar manner to that provided by a petrol engine, which, when in gear, gives adequate braking for coasting purposes without any harmful effects on the cardan shafts, universal joints or differential gears. By employing this type of electric brake the life of the brake liners is materially lengthened, as they are not, of course, used by the electric braking, and are only brought into action when the vehicle has to be stopped and their application then takes place at a comparatively low speed.

The electric brake is usually provided with two notch positions so graduated that retardation is well within the limit of passenger comfort.

With a trolley bus which weighs, when fully loaded, say, 12 tons, the efficiency of the "English Electric" system of rheostatic braking is such as to permit coasting down a grade of one in eighteen at a speed of from ten to twelve miles an hour on the second brake notch. The first brake notch permits a coasting speed of approximately 15 miles an hour.

Another important point to which attention may be drawn is the interlocking of the rheostatic brake with the main control in such a way that power is cut off when the brake is applied, so that it is impossible for driving power and braking action to be applied at the same time.

In conclusion, it may be said that the individual pieces of apparatus are mounted with due consideration to convenience of inspection and maintenance, and connecting up.

A New Trolley Bus Order.

The Wallsall Corporation has placed an order with the English Electric Company for two double-deck, 3 axle buses of the "A.E.C. English Electric" type.

Opening of Chenderoh Power Station.

This water power station of the Perak River Hydro-electric Power Company was formally opened on June 28th by His Excellency the High Commissioner of the Federated Malay States, Sir Cecil Clementi, who started up one of the generating sets in the presence of His Highness the Sultan of Perak and a distinguished company.

The main generators are three "English Electric" vertical-shaft alternators, each having a normal output of 9,000 kW. at a speed of 93.75 r.p.m. These machines are designed to carry continuously an overload of 20% at .875 power factor corresponding to a load of 12,350 kVA., and are wound to give a 3-phase, 50-cycle supply at a pressure of from 6,230 to 6,930 volts.

The steam station at Malim Nawar which will now work in conjunction with the Chenderoh Station has enabled the undertaking to supply a rapidly increasing load during the construction of the hydraulic works. It is equipped with three 6,000 kW. "English Electric" steam turbo-alternator sets and condensing plants.

Large Motors for the Steel Industry.

It is satisfactory to be able to record that in spite of the adverse conditions under which the steel industry has been suffering, a number of prominent firms engaged in this business are pressing forward with schemes for improving the economy of their plants, especially by the installation of modern electric drives.

The long association of The English Electric Company with the application of electric power to heavy rolling mill drives, and their unrivalled experience in this class of work, has enabled them to put forward a number of schemes which have shewn such great advantages over alternative proposals that they have secured a large share of the orders that have been placed.

In the following notes reference is made to two contracts from both of which it is anticipated that substantial economies will result with consequent benefit to the competitive position of steel producers who have realised that properly designed electric driving is undoubtedly one of the surest means of reducing their costs of production.

A Large Slow-speed Induction Motor.

The present-day practice in the use of induction motors for the driving of rolling mills is usually to employ motors of comparatively high speed coupled to the mill through reduction gearing. An induction motor designed to operate at a sufficiently low speed for it to be coupled directly to the rolls of a roughing mill, is, therefore, of some interest, especially if, as in the present case, it is of considerable size.

Fig. 1 shows a motor of this kind recently completed at the Stafford Works of the Company. It is designed to give an output of 700 h.p. continuously at a synchronous speed of 65·2 r.p.m. when operating on a 25-cycle, 2,750-volt supply. In spite of its low speed the machine has a peak capacity of 1,750 h.p. in view of the duty for which it is required.

It will be seen from the illustration that the stator is of fabricated construction, that is to say, it is built up of steel plates united by electric welding,—a type of construction now being used extensively by the Company for many of its products. It will also be observed that the endshields are made in segments, any of which can be removed independently for examination of windings.

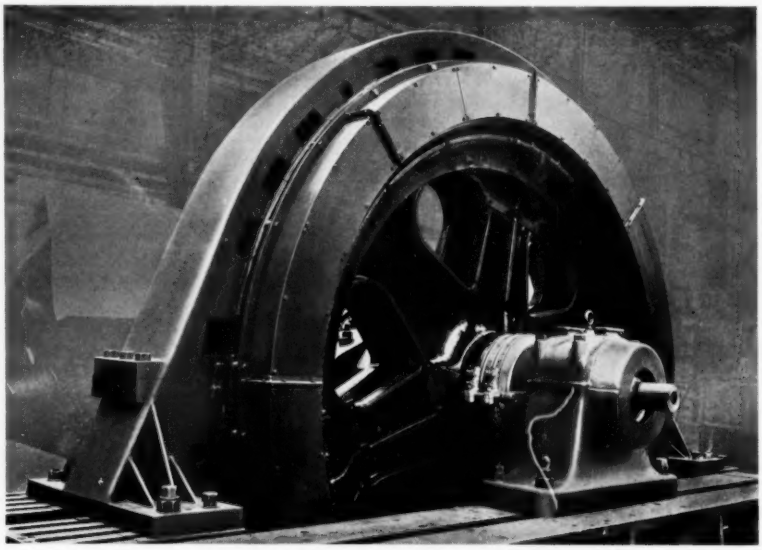


Fig. 1.—65·2 R.P.M. Induction Motor; Peak Output 1,750 H.P.

Fig. 2 which is a view of the stator during the process of being wound, shows that the frame is constructed in two portions. This was necessary on account of transport requirements, since the outside diameter is 14 ft. and the distance across the feet 16 ft. 4 ins.

The rotor, which is shown in Fig. 3, is of exceedingly massive construction, and has a

diameter of 10 ft. 7 ins., and a total weight of approximately 11 tons. Although this rotor with its shaft is of greater size than would normally be transported by rail, it was decided to despatch it complete with its shaft in order to minimise the amount of erection work to be done on site, and arrangements were accordingly made with the railway company for it to be carried during a week end when special facilities could be given.

The motor will be coupled to the flywheel on the mill shaft through a flexible coupling, and will be provided with a slip resistance connected in the rotor circuit, so that the speed may fall during the peak load, thereby enabling the flywheel energy to be utilised for reducing the maximum power demand from the supply mains.

New 27-in. Reversing Mill Equipment.

Messrs. Brown Bayley's Steel Works, Ltd., the well known firm of steel makers, whose works are situated in Sheffield, have placed an order with the English Electric Company, for the whole of the electrical plant and apparatus required to drive their existing 27 in. Reversing Mill.

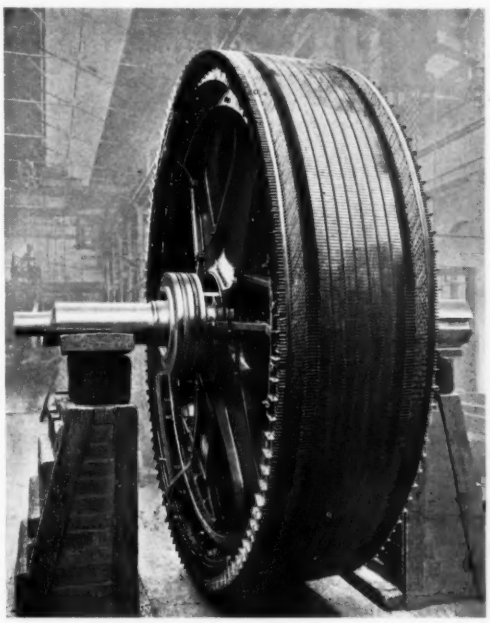


Fig. 3.—Rotor of Slow-speed Induction Motor.

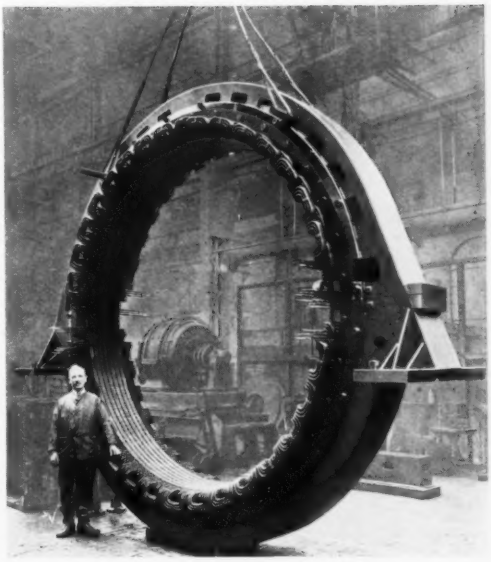


Fig. 2.—Stator of Slow-speed Induction Motor.

This mill is at present driven by a steam engine, and it was necessary to reduce the cost of power required for rolling. Many alternative schemes were examined and various equipments were inspected both in this country and on the Continent ; after an exhaustive examination of the problem, it was decided that the electric drive employing energy supplied by the Sheffield Corporation, would be the most economical.

The mill rolls alloy and high carbon steel ingots 23 cwts. in weight, down to billets and small sections. When the change-over takes place, it will be directly driven by a single direct-current motor having a present maximum output of 6,000 h.p., the machine being so designed that at a later date, this output may be increased to 12,000 h.p. by the addition of further generating capacity, as described later.

The motor will be of the forced-ventilated type, and will be supplied with clean air by means of a fan and filter. The whole machine will weigh approximately 120 tons, and the rotating portion about 50 tons, the shaft end being 24 ins. in diameter. A flexible coupling of the Wellman-

Bibby type is to be interposed between the motor and the pinions on the mill.

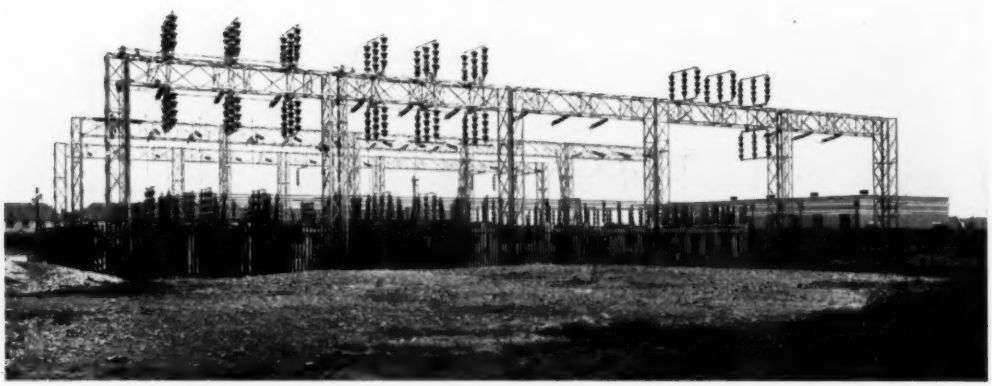
In order that it may be quickly and economically varied in speed to suit the rolling operations, the mill motor requires to be supplied with variable-voltage direct current, whereas the Corporation supply is 11,000 volts alternating current. The equipment will therefore include a converting set, consisting of an 11,000-volt, 2,000-h.p. motor driving a large direct-current generator, interposed between the supply mains and the mill motor.

It should further be noted that as the load on the mill motor is exceedingly variable, the converting set will be provided with a cast-steel flywheel weighing 21 tons, and having a rim speed of approximately 240 miles per hour ; the object of the flywheel is to prevent excessive peak loads being imposed on the mains.

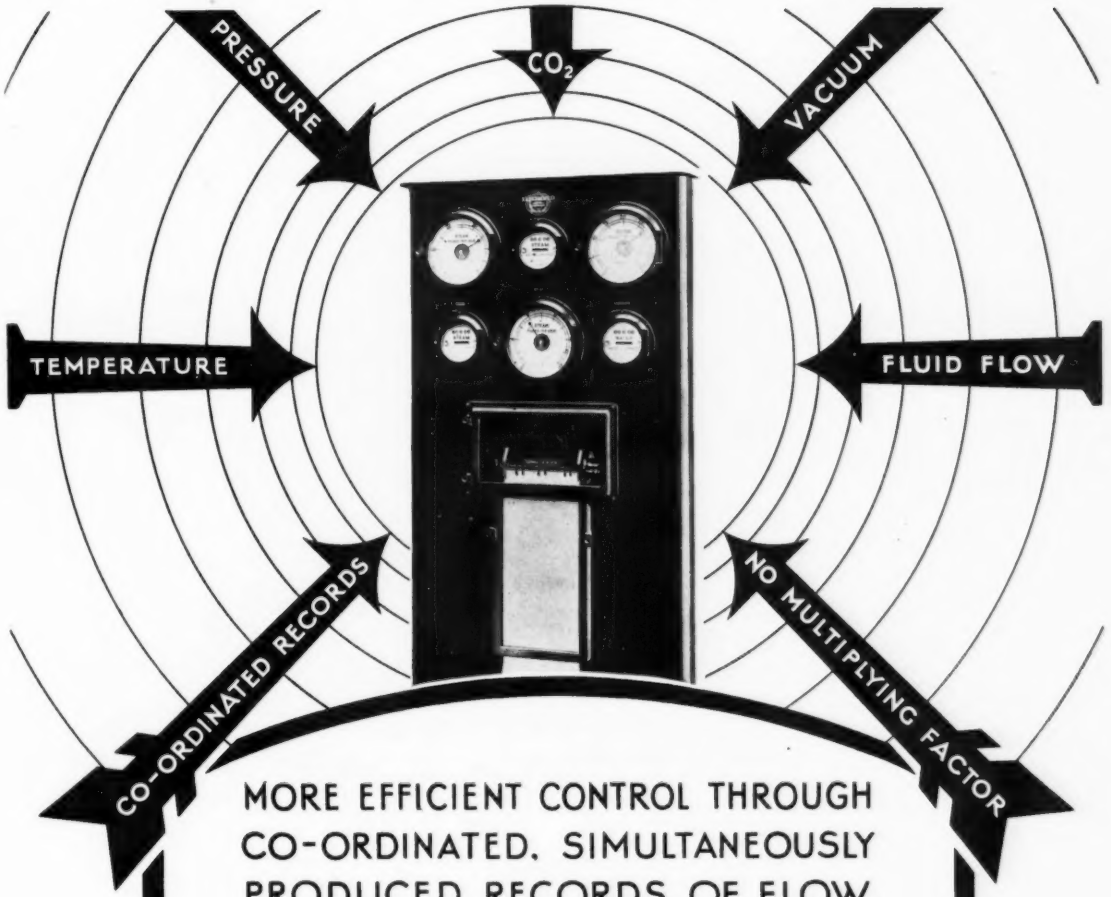
Speed control of the large motor is carried out by control of its field current and that of the generator which feeds it, and separate exciter sets for these .field systems will form part of the equipment. Hence the main circuits, which carry very heavy currents, always remain closed, and the control gear, which has to deal with small currents only, can be made very simple and convenient for direct handling by the mill driver; the whole of the control both in regard to direction of rotation, and to the value of the motor speed, is carried out by a single lever which the driver operates. The speed of the mill may be altered from 70 r.p.m. in one direction, to 70 r.p.m. in the opposite direction, almost as fast as the driver can move his lever.

With the addition of a second generator to the converting set, the maximum speed of the mill motor will be raised at a later date to 110 revolutions per minute, and it will then give 12,000 h.p.

It is only in the case of the largest installations that this particular form of control is used, and the equipment in question will form the twenty-second installation of a similar type supplied by The English Electric Co., for this country and abroad. Fifteen of these equipments are employed in the steel industry, and the remainder in mills dealing with other metals.



132,000-volt Central Electricity Board Switching Station near Brighton. One of twelve under construction for the S.E. England scheme, with oil breakers of 1½ million kVA. capacity.



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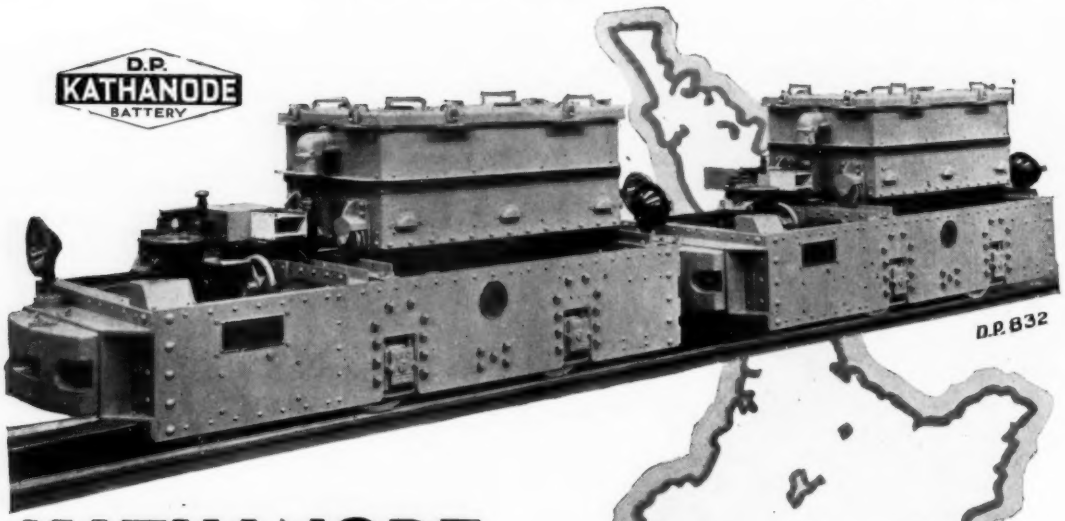

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The illustration shows two of the electric locomotives recently supplied by the English Electric Co., Ltd., to a customer in Wellington, New Zealand. Each locomotive is capable of hauling a 6-ton trailing load against a gradient of 1/60 at approximately 6 miles per hour, and depends for its power upon Kathanode Batteries.

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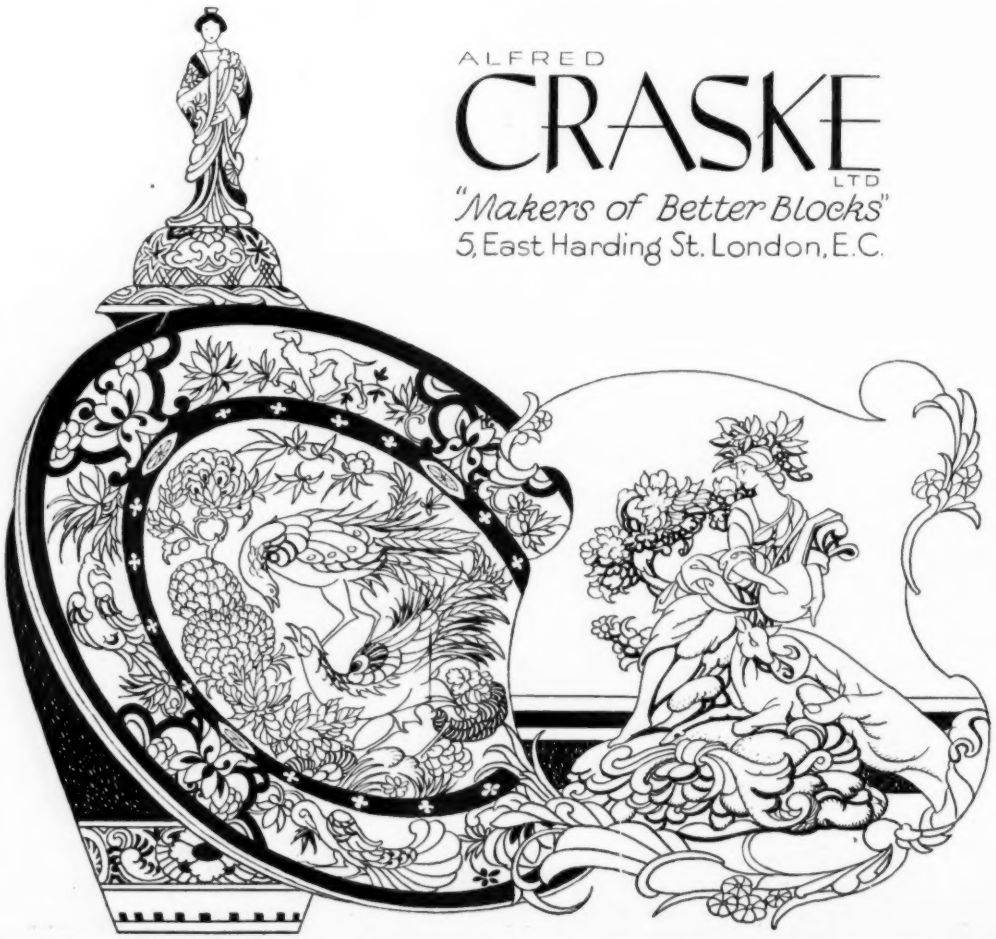

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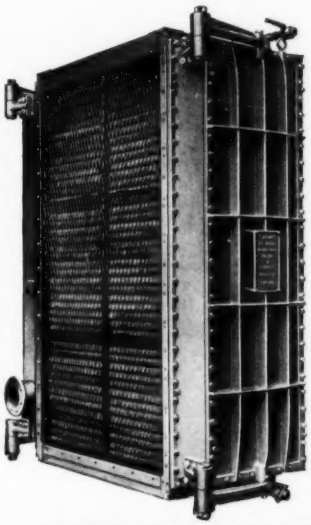

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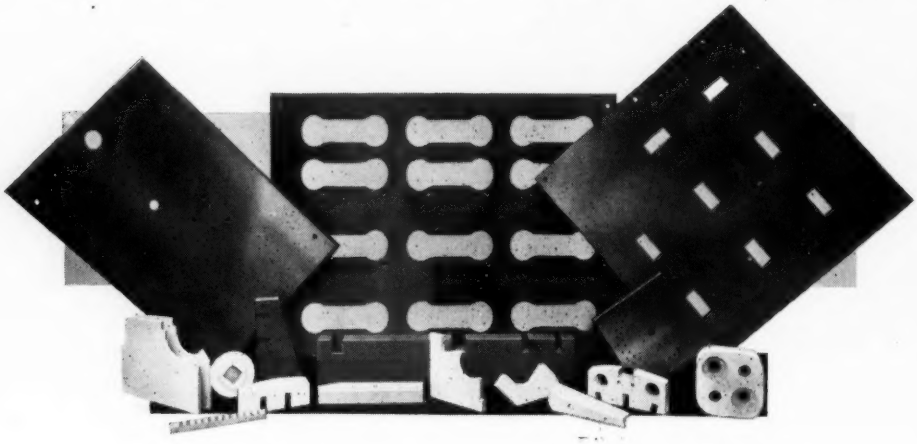

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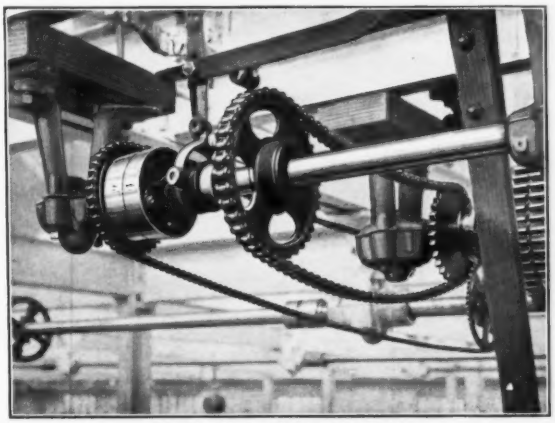

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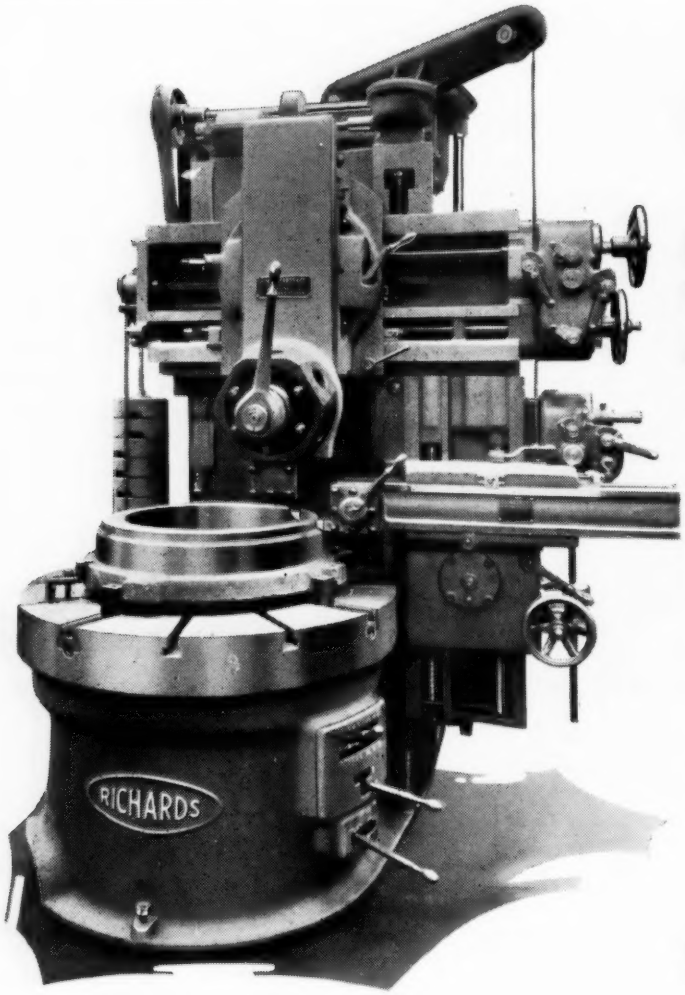

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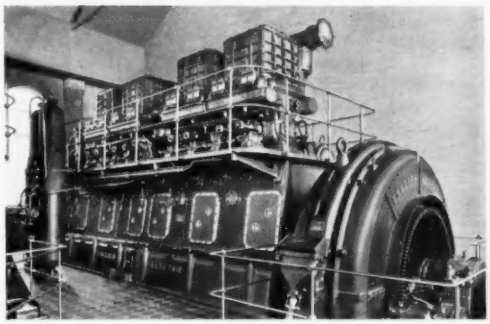

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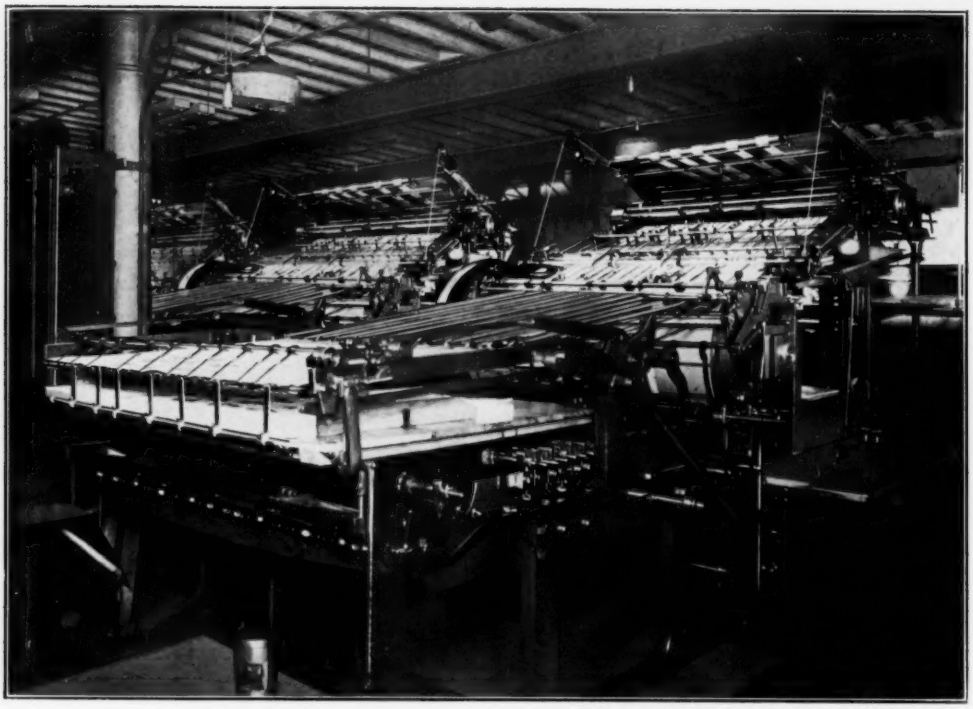

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